U.S. DEPARTMENT OF ENERGY | Office of Science

Office of Project Assessment
CD-1 Review Report on the

Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Project

at Thomas Jefferson National Accelerator Facility

October 2020

EXECUTIVE SUMMARY

A Department of Energy/Office of Science (DOE/SC) CD-1 review of the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Major Item of Equipment (MIE) project, located at the Thomas Jefferson National Accelerator Facility (TJNAF) was conducted remotely, due to the COVID-19 pandemic, on October 13-15, 2020. The review was conducted by the Office of Project Assessment (OPA) at the request of Timothy J. Hallman, Associate Director of Science for Nuclear Physics (NP). The review was chaired by Ethan Merrill, OPA.

The purpose of the review was to assess the overall readiness of the MOLLER project to request Critical Decision (CD) 1, Approve Alternative Selection and Cost Range. The MOLLER project team is making good progress in all areas of the project and is maintaining strong project management discipline. The Committee noted that the scientific case for MOLLER continues to be outstanding and extremely compelling. It provides a unique window for physics beyond the standard model with sensitivities not accessible in other accelerator facilities in the foreseeable future. The Committee determined the project has met the requirements for CD-1 and is ready to proceed to CD-1 approval.

Target and Spectrometer

The spectrometer Level 2 Control Account Manager (CAM) is a senior magnet engineer, and the Level 2 Technical Leads include highly experienced TJNAF engineers and a University Professor experienced in working at TJNAF. The spectrometer team is strong, with many team members coming from the successful 12 GeV upgrade, and hence are well versed in project delivery. The target group is highly experienced and can build on what they have learned from the Q-Weak target. Most critically, the project team knows how to work effectively and efficiently at TJNAF and in the Hall A.

Computational Fluid Dynamics (CFD) simulations have been used to improve the target cell design, resulting in a significant calculated reduction in relative density loss in beam volume, and importantly a dramatic reduction in LH2 density variations at the entrance and exit of the target.

The project team should strive to improve clarity in roles, responsibilities, authority and accountability (R2A2) of the various teams from universities and TJNAF working on specific components, e.g., the interplay between coil design and physics simulations, and ensure continued involvement throughout the project.

The simulation tools are critical for the optimal design of the spectrometer and to inform engineering tolerances. The project is encouraged to further develop the tools to allow rapid feedback to the design team, both for the near-term design needs as the project proceeds towards CD-2, but also to guide decisions based on as-built hardware that arrives during construction.

It may be possible to use the physics simulations tools to identify limits on allowable total magnetization in the various regions of the spectrometer, which can then be used by engineering as a budget for the selection and usage of magnetic materials such as steels.

The CFD calculations on the target indicate that significant improvement in performance and can be gleaned through design optimization. Although there are good indications that the CFD results agree with experiments on previous targets, it would be prudent to have a CFD expert on early design reviews to make sure the physics are properly captured.

The Committee suggested that the decision to forego testing the target system with liquid neon be reviewed and confirmed by a safety committee.

The conceptual design of the target appears sound. It is based on the successful Q-Weak design and will be executed by the same personnel. There are no obvious showstoppers, although a significant amount of engineering is still required before CD-2 to complete the design.

The project intends to have the toroid vendor fabricate one prototype downstream (DS) coil, before proceeding with the production coils. The spectrometer team developed two DS coil options, a hybrid coil configuration, and a segmented coil configuration, based on guidance from a Magnet Advisory Group.

The project should proceed quickly with the comparative analysis between the “hybrid” and “segmented” DS torus designs, as the down-select decision will likely impact many downstream decisions, with the planned vendor procurement stages. This is particularly important in view of the tight coupling between physics requirements and final magnet/support design.

The project intends to use a single vendor for the toroid coils. Given the high visibility and tight production schedule, the Committee strongly encouraged the team to plan for significant on-site presence so that issues are identified and addressed early. It would be highly informative to include: 1) a detailed test plan for the prototype coil evaluation, including driving well beyond design current to probe actual operational limits, and 2) to perform destructive post-mortem inspection of the coil, for example in the tightest bend regions, to evaluate for example conductor deformations and coil-pack impregnation quality.

The project team should use the simulation capabilities to check the tolerances on the dimensions of the coils for the downstream toroid to determine if looser tolerances can be supported, possibly resulting in a cost reduction.

The project should evaluate whether residual radioactivity will be important when replacing a component that has suffered radiation damage.

TJNAF management should identify and commit the space to be used for outside-the-hall assembly, especially for the DS toroid.

Optimization of the target windows design (where significant heating is expected) should be completed as soon as possible after CD-1.

The labor profiles for target and spectrometer show high spikes that may be difficult to effectively manage. The project should perform load leveling to the degree possible to improve labor balance. For example, the schedule leading to 90% design for the target is labor-limited and on the critical path for CD-2/3. The project team could work with TJNAF management to provide additional design resources to ease that schedule.

Installation in the Experimental Hall is on the critical path for project completion. Extra care needs to be taken to choreograph the removal of Super Bigbite Spectrometer (SBS) and the installation of MOLLER.

Both target and spectrometer schedules show most procurements starting in January 2023, presumably linked to CD-3 approval. The Committee encouraged a more realistic distribution of both design and procurement schedules as part of the load leveling effort, as well as consideration of realistic funding flow. If procurements are more stretched out over time, care needs to be taken to receive the items in the order needed for installation.

Integrating Detectors

The main thin quartz 6-ring Cerenkov and thick ShowerMax integrating detectors are based on proven technologies, and do not represent technical risk. The detectors include an air light guide coupling a quartz-face photomultiplier tube (PMT) to the thin quartz. Qualification of a second vendor for the quartz is being considered. This would include optical and radiation-tolerance considerations. Prototyping of the critical ring 5 thin quartz detector units is planned. The thin quartz detectors will experience final doses as high as 170MRad in ring 2 and 70 MRad in ring 5. Radiation testing of all detector components (quartz, light guide, and electronics) has been done and is planned for future prototypes.

Integrating detector electronics are based on previous work (Q-Weak), which has already satisfied noise requirements for MOLLER. The PMTs are operated with 10 uA anode current and gain approximately 500 to limit total charge and ensure the PMTs last for the experiment duration.

Dry air is being considered to limit possible oxidation of the light guide coatings.

Spare detector elements are included in the project's plans to allow for change-out and/or re-location of any detector elements exhibiting aging.

Preproduction prototyping prior to serial production, including final dimensioning and remaining materials choices, remains to be done once final detector geometry is defined. Final prototypes remain to be built for rings other than 2 and 5.

Tracking Detectors

The tracking detector system is composed of three components, all of which are established technologies: 1) four layers of 7-sector triple GEM detectors on rotatable stages; 2) pion Cerenkov detectors, with trigger scintillator-GEM pairs in two sectors; and 3) the scanner detector.

GEM detectors are only for use in counting mode. The pion detectors and scanner detector can be used during both integrating mode measurement time and in counting mode. A set of sieve slits are being designed, with several different hole patterns, to provide efficiency, orientation, and full area checks of the spectrometer acceptance. The choice of GEM technology for tracking detectors is well motivated. The planned layout with seven sectors is constrained by cost and focuses on reusing existing developments and even components. During integrating mode (asymmetry) measurements, GEM detectors slide on rails radially out of the flux region.

GEM detectors will be instrumented with electronics from SBS. MOLLER requires approximately 50k channels; in excess of 120k channels will be available from SBS.

Data Acquisition and Trigger

The DAQ system includes two separate DAQs, one for production (integration) mode and one for counting mode. The DAQ systems are built using the CODA (CEBAF Online Data Acquisition) hardware and software framework. Integration mode DAQ and trigger requires collection and transfer of 100% of the helicity window data, without deadtime, at a helicity flip rate of 1.92 kHz.

The counting mode DAQ must support triggers derived from trigger scintillators, quartz detectors, or pulsers at rates from 10kHz to 300 kHz. Fully corrected asymmetry analysis with 100% throughput is required, with disk space to hold results spanning several days.

Integrating Analog to Digital Converters (ADCs) are the next generation of Q-Weak ADC modules and are built by TRIUMF. Key improvements from the previous generation are increased input bandwidth (now approximately 1MHz) and increased ADC sampling rate (now 15Msps). A 2-channel prototype of the new integrating ADC is to be tested this year by the University of Manitoba and TRIUMF. A complete schematic exists, and firmware development is underway. The printed circuit board layout is beginning for the full board.

Counting mode electronics uses the standard TJNAF pipelined FADC and VXS Electron Trigger Readout Board plus VXS-based trigger processors. GEM readout uses standard TJNAF multipurpose digitizer modules.

Helicity-correlated feedback requires a ten-second accumulation and readout. Information from the injector is included. Requirements for the workstation for helicity-correlated feedback, for the several (ten) workstations for data quality monitoring and monitoring transverse beam polarization, and for disk storage are established. All requirements are met by the CODA framework noted above.

Scattered beam monitors (small and large angle monitors and diffuse beam monitors) fall under WBS 1.07. Detectors are small quartz + air light guide + PMT assemblies, like integrating detectors.

MOLLER has a potential opportunity to receive funding from the National Science Foundation (NSF) mid-scale project program. If this funding is received, a portion of the GEM modules, trigger scintillators, and detector supports of the tracking detectors, as well as a portion of the ShowerMax integrating detectors and DAQ and trigger will be removed from the DOE MIE scope.

Infrastructure

Infrastructure (WBS 1.06) includes incoming beamline modifications, hall modifications, particle shielding and electronics hut, cables and low-voltage/high-voltage power supplies, and detector frames and supports. Installation of the experiment is also included in this WBS.

Shielding requirements have been evaluated using GEANT4 simulations. Current dose estimates are a factor of five below the limit for expecting damage effects. Shielding studies show that the allowable dose at the TJNAF site boundary will not be exceeded and detailed low-conductivity water (LCW) checks are proceeding. Checks between results derived from GEANT4 and those from FLUKA have been made and show agreement within a factor of two. Shielding materials include standard concrete blocks, lead shield walls downstream of the target, and monolithic collimators. Examination of certain materials choices, in particular the lead for activation and proper disposal post-experiment, are under study.

Dependencies involving ongoing TJNAF upgrades are being tracked by the infrastructure team. This includes and power work in Hall A, injector upgrades, Compton and MOLLER polarimeter upgrades, the upgraded raster system, and a new End Station Refrigerator (ESR2). ESR2 is a critical dependency to enable use of the high-power LH2 target.

The maturity of the design of all the detector systems, DAQ and trigger, and the detail of the planned implementation is very impressive, particularly for this early stage of the project. The project team and scientific collaboration consists of members with extensive expertise and excellent track records in performing high-precision parity-violating experiments at both TJNAF and SLAC (E158). The project team has the required expertise and experience to successfully execute the final design and construction.

As the accelerator facility, which has the technical expertise and infrastructure for delivering high-quality polarized beams for precision parity-violating experiments, TJNAF is the ideal location for performing the MOLLER experiment.

The scientific goals articulated in the MOLLER proposal submitted to DOE in 2014 are likely to be successfully accomplished based on the Conceptual Design. The threshold and objective Key Performance Parameters (KPPs) for the detectors and DAQ are appropriately defined and provide scope contingency to the project. The Ultimate Performance Parameters (UPPs) are aligned with the ultimate MOLLER scientific goals.

Not enough details were presented on the estimated systematic errors, in particular, there is no information on the uncertainty associated with these systematic errors in addition to the central values. While this is to be expected at the CD-1 (conceptual design) stage, it will be essential to present further information to support the estimates of the systematic uncertainties prior to CD-2 and should be included in the Technical Design Report.

While the KPPs for the integrating MOLLER ring detectors and the GEM detectors are clearly defined, it is not clear how the performance requirements of the other detector components, including the ShowerMax and pion detectors, are quantified. Additional studies to quantify the impact of the performance of these detector systems on the ultimate sensitivity of the experiment should be considered prior to CD-2.

The adopted approach of using established detector technologies and electronics systems is a sound one, and greatly reduces potential risks to the project. At the same time, care has been taken to confirm that these detector technologies will deliver on the physics goals of the experiment, which was clearly communicated.

While the detector technologies planned for MOLLER are well-established, the project should re-evaluate technical risks that could impact their progress. While these may be a low likelihood, a detector system with no risks associated in not meeting specifications seems unrealistic. An updated risk evaluation should be prepared prior to CD-2.

The detailed design of the spectrometer and geometry of the final detector systems are very tightly coupled. As the detailed interface control documents are still being developed, the project needs to be careful to ensure that changes during design impacting other subsystems are communicated promptly to all affected parties. The current approach is to have several people attending all relevant meetings to maintain a comprehensive view of the project, which is a good approach. The project may also consider advancing development of draft Integrated Control Documents to capture key areas of coupling.

The SBS-based front-end electronics APV-chip readout system for GEM readout is used equipment. This is an understandable choice but has a risk associated with it. It assumes that APV chips are fully functioning after SBS even though 17k channels (approximately 130 readout chips) are provided from the University of Virginia (UVA). The risk associated with this choice and a risk mitigation plan was not fully presented.

UVA has a strong track record at TJNAF for building GEM detectors, which requires a great deal of care in Quality Assurance of components and also during the assembly. The effort will significantly benefit if the effort is shared with other institutions since UVA also has a significant responsibility, such as the SoLID (Solenoidal Large Intensity Device) detectors and other future commitments.

The GEM detector efforts heavily rely on the delivery of components from CERN. A commitment from the CERN photolithographic group is essential. This holds for the GEM detectors and the two-dimensional board and potentially mechanical frames—it is not clear if those are also acquired from CERN. A focus on maintaining and establishing good communication as the project progresses will be essential.

Using the same vendor/manufacturer from Italy on the front-end electronics and hybrid system fabrication as for SBS is the right choice. A commitment will be necessary as the project proceeds.

The plan to build the DAQ system based on CODA and established electronics modules ensures minimal risk to the project, without compromising any required performance.

The importance of coordination between the project and the CEBAF facility is clearly understood by the project. The management support and inclusion of key Hall A personnel in the project team is evidence of this. The project should work to ensure that this communication remains strong.

Installation of the experiment falls under the Infrastructure WBS. The project team should consider separating the infrastructure and installation parts of the WBS and possibly having different CAMs for these functions.

The schedule for installation of the experiment is very tight. The project team should keep a close eye on the removal of the SBS equipment and the installation schedule. A detailed installation plan will be needed before moving to CD-2/3.

The project team may want to consider adding external milestones related to the SBS removal to the Primavera (P6) schedule to be able to note any future effects on their critical path, particularly when the MOLLER experiment reaches the installation phase.

Good polarization behavior for the re-configured beamline is critical to the MOLLER experiment. While this falls outside of the direct project scope, the project team should closely monitor the commissioning and performance of the beamline and consider adding key commissioning milestones to the P6 schedule.

Project Management, Cost and Schedule, and Environment, Safety, and Health

The project established an Integrated Project Team (IPT) and a Federal Project Director (FPD) has been assigned. The project team contains a Project Manager, Deputy Project Manager, Project Engineer, and Safety Lead. The TJNAF Project Management Office provides Project Controls. TJNAF procurement is an overhead function.

The project team developed a WBS that includes all required project scope including a LH2 target, a resistive water-cooled toroid spectrometer magnet, integrating detectors, tracking detectors, Hall A infrastructure and integration, and DAQ and trigger.

The project team developed KPPs including threshold and objective criteria, and also identified UPPs for full scientific discovery potential. The KPPs are well developed for this stage.

The KPPs include some scope contingency for thin quartz, ShowerMax, and GEM modules. A few other possibilities were mentioned as candidates for scope contingency and the total potential savings was estimated to be about $2 million.

The project team developed required documentation to effectively deliver the project, including: Preliminary Project Execution Plan (PPEP), Risk Management Plan, and Preliminary Hazard Analysis Report (PHAR).

The project identified an opportunity to reduce the Total Project Cost (TPC) with the delivery of portions of project scope through a NSF grant, as well as funding from a CFI/Research Manitoba grant. Decisions from the NSF and CFI are expected by the end of the calendar year.

The project has a TPC point estimate of $51.2 million. Cost contingency is $13.3 million, which is 35% of work to go. Estimate uncertainty accounts for 28% of the cost contingency being carried.

The project has a cost range of $42.0-60.1 million, based on project definition that is at the low end of Class 2, from the DOE Cost Estimating Guide. Project definition was estimated to be in the range of 39-62%, based largely on CAM judgement.

The project has an early finish CD-4 date of August 2025. The Level 1 milestone date for CD-4 is August 2027, resulting in 24 months of schedule contingency.

The project team developed a labor profile and assigned personnel by skill to the project needs. Some subcontract labor will be required to complete the project as planned.

A critical path schedule was developed—it runs through CEBAF operations, Hall A modifications, and equipment installations.

There are 66 discrete risks being tracked, five retired, and 61 active. Four high risks have been identified including funding profile issues, staging area availability, shielding material adequacy, and detector power supply grounding. Monte Carlo analysis of the cost and schedule risks was been performed. P80 requires $11.3 million of cost contingency and 11 months of schedule contingency. The project currently carries $13.3 million and 24 months of contingency.

The P6 schedule is resource loaded with FY 2019 rates and escalated at 3% through the outyears. The project team planning accounted for COVID-19 impacts through FY 2021.

The project schedule consists of 1,773 activities inclusive of the REQN, AWARD, and ACCEPT tasks, has no lags or leads, no negative float, and only one hard constraint, which is the CD-4 Level 1 milestone date.

The project has a qualified Project Safety Officer who attends Hall A weekly meetings, participates in the TJNAF lessons learned process, and receives “safety flashes” from the ESH group for DOE lessons learned.

The project performed a National Environmental Policy Act (NEPA) analysis and was granted a Categorical Exclusion based on criteria B1.31 of 10 CFR 1021 subpart D.

The project has a signed PHAR that will continue to be reviewed and updated throughout the project. COVID-19 is not currently addressed in the PHAR.

SBS installation has been delayed by five months due to COVID-19. This is impacting the available resources for MOLLER.

TJNAF will have personnel assigned and maintain design authority on all equipment built offsite.

The project will adhere to the TJNAF Integrated Safety Management Program and ES&H Manual.

The preferred alternative to execute MOLLER at TJNAF is reasonable but the lifecycle cost has only been presented for the preferred alternative. A comparison of alternatives in present value has been requested of other projects.

The project has a cost range of $42-60.1 million, which is consistent with a Class 2 estimate and supported by the -5% to +15% range selected by the project. The estimate may be better defined as Class 3 or 2/3. The high end of the range equates to 66% contingency on the Baseline at Completion (BAC) that should be adequate for a project at this stage. Basis of estimate is dominated by prior experience (44%) and engineering judgement (33%). Vendor budgetary estimates are 11% of the estimate.

The project schedule was analyzed with Acumen Fuse and had a Schedule Quality score of 86%, which is particularly good. However, after cleaning up the redundant logic using Fuse's Cleanse feature a 92% schedule quality was obtained.

The project should improve clarity in R2A2 of the various teams from universities and TJNAF, particularly when collaborating on a common component. Work with the institutions and the program office to ensure their continued involvement throughout the project.

The project should consider updating the risk registry with an Expected Monetary Value (EMV) column to allow for a quick comparison with existing contingency levels to ensure remaining contingency is sufficient to cover project risks. This will need to be done in conjunction with an analysis of the remaining uncertainty as well.

The ESH and quality teams should consider trips to partner universities to establish contact with their counterparts, share lessons learned, and heighten awareness of ESH&Q issues across the project.

The project does not have an identified quality professional on board to guide development of a tailored quality plan and provide support when questions and issues arise. This should be rectified prior to CD-2.

The design of the hydrogen target is driving the project's CD-3 date causing other systems with completed designs to wait and potentially lose momentum. This is largely a resource issue at the level of one or two people with the requisite experience. The project and TJNAF are encouraged to work together to address this resource bottleneck to bring the hydrogen target CD-3 schedule more in line with the other systems.

The project should perform load-leveling on the schedule and evaluate opportunities to accelerate the design schedule to enable more realistic procurement and installation dates.

The PPEP, Section 8.2.1 should be updated addressing the P80 estimates obtained from the Monte Carlo analysis (consistent with homework response of $2.4 million vs. $3.3 million for discrete risks).

Key Recommendations

- Enhance engineering and designer support to the target group within the next six months to advance the design off the critical path.
- Develop a detailed, resource-loaded installation plan prior to CD-2/3.
- Update the PPEP prior to the CD-1.
- Add a Quality Assurance professional to the project before CD-2/3.
- Perform load-leveling on the schedule and evaluate opportunities to accelerate the design schedule, within the next six months, to enable a more realistic and optimized procurement and installation schedule.
- Proceed to CD-1.

CONTENTS

1. INTRODUCTION

The Office of Nuclear Physics is funding the Method of Lepton-Lepton Electroweak Reactions (MOLLER) Major Item of Equipment (MIE) at the Thomas Jefferson National Accelerator Facility (TJNAF; Figure 1-1). MOLLER will provide the ability to measure parity violating asymmetries in Møller scattering at an unprecedented level of precision. Even small departures from the theoretical value could signal the presence of electron-electron scattering not accounted for in the Standard Model of particle physics. As the most sensitive low energy measurement of a flavor-conserving purely leptonic interaction in the world, MOLLER will also be a significant component of the global strategy to discover signatures of a variety of physics that could escape detection at the Large Hadron Collider (LHC).

The specific measurements enabled cannot be carried out in any other existing or planned facility. The science goals of MOLLER have been peer reviewed and endorsed both by the Nuclear Science Advisory Committee (NSAC) and by an independent external panel of experts. Critical Decision 0 (CD-0), Approve Mission Need, was obtained on December 21, 2016, with a CD-0 range of $25-35 million.

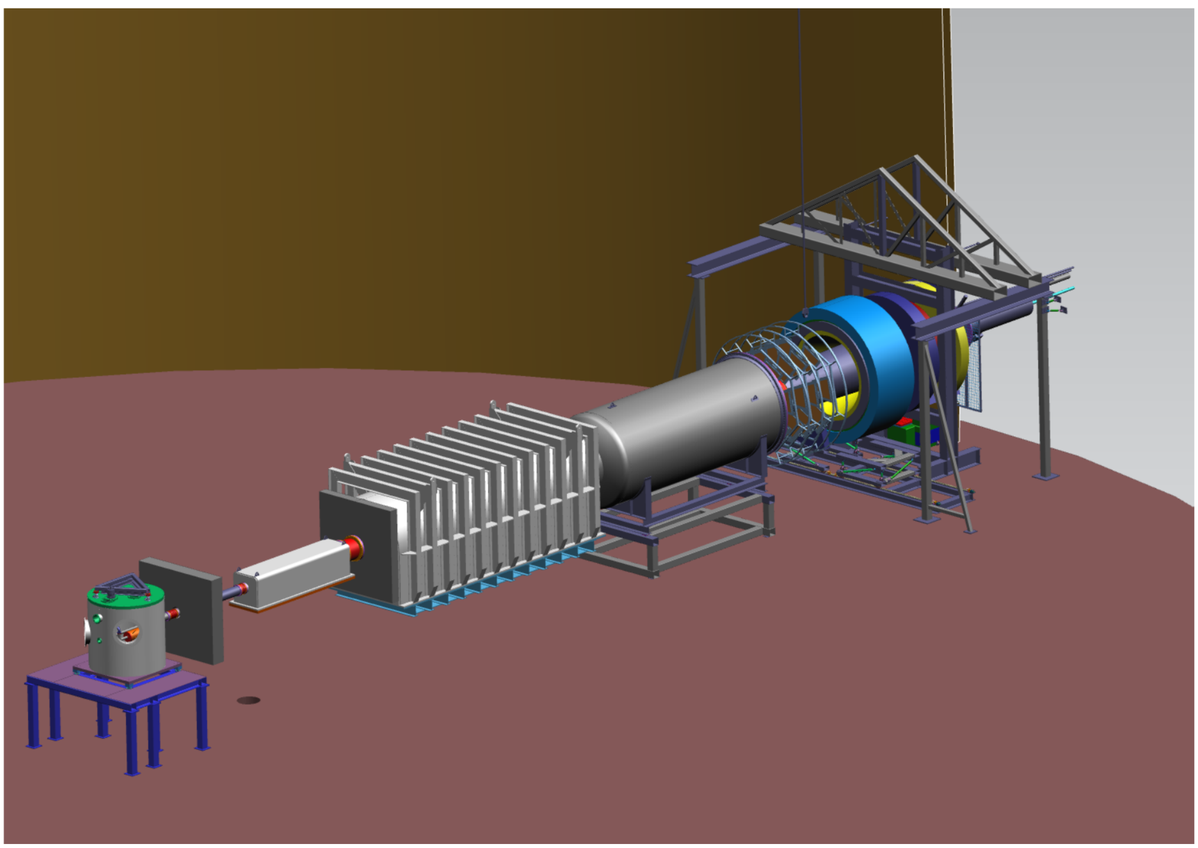

Figure 1-1. MOLLER, to be sited in Hall A at TJNAF, consists of a liquid hydrogen target, spectrometer, tracking detectors, integrating detectors, data acquisition and infrastructure modifications.

In an August 11, 2020 memorandum (Appendix A), Dr. Timothy J. Hallman, Associate Director of the Office of Science for Nuclear Physics (NP), requested that Kurt Fisher, Director of the Office of Project Assessment (OPA), Office of Science (SC), conduct a review of the MOLLER MIE, which was conducted remotely on October 13-15, 2020. The purpose of this review was to determine if the project had fulfilled the requirements for CD-1, Approve Alternative Selection and Cost Range, in support an Energy Systems Acquisition Advisory Board (ESAAB) Equivalent meeting anticipated later in the year. Ethan Merrill, OPA, chaired the Review Committee (Appendix B).

Committee members were chosen based on their technical and/or project management expertise, and experience with building large scientific research facilities, as well as their independence from the project. The Chairperson organized the Committee into three subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise. The MOLLER MIE team and DOE/SC Headquarters staff jointly developed the agenda (Appendix C). Comparison with similar projects was the primary method for assessing technical requirements, cost estimates, schedules, and adequacy of the management structure.

2. TECHNICAL SYSTEMS EVALUATIONS

2.1 Target and Spectrometer

2.1.1 Findings

The spectrometer Level 2 Control Account Manager (CAM) is a senior magnet engineer, and the Level 2 Technical Leads include highly experienced TJNAF engineers and a university professor experienced in working at TJNAF. Most have significant experience in delivering the CEBAF 12 GeV upgrade.

The project developed significant simulation tools to guide the determination of requirements for the target and spectrometer.

There are no plans to perform system tests with liquid neon, as it is customary for smaller liquid hydrogen target systems, prior to run the MOLLER target with liquid hydrogen. One reason is the large cost of neon, in the tens of thousands of dollars. Another is that due to the confidence gained from Q-Weak and other recent hydrogen target systems, careful design and simulations are sufficient.

CFD simulations have been used to improve the target cell design, resulting in a significant calculated reduction in relative density loss in beam volume, and importantly a dramatic reduction in LH2 density variations at the entrance and exit of the target.

The project intends to have the toroid vendor fabricate one prototype coil, before proceeding with the production coils.

The spectrometer team developed two options, a hybrid coil configuration and a segmented coil configuration, based on guidance from a Magnet Advisory Group.

The spectrometer team maintains a list of prohibited and allowed materials.

Simulations were presented of radiation loads on major elements in the spectrometer Hall A, including the magnets.

A high-level schedule was presented, showing spikes in manpower needs in FY 2022, and completion of designs of many elements with float to CD-3.

2.1.2 Comments

The spectrometer team is strong, with many team members coming from the successful CLAS12 (12 GeV) upgrade, and hence well versed in project delivery. Most critically, the project team knows how to work effectively and efficiently at TJNAF and in the Hall A.

The Committee suggested the project improve clarity in roles, responsibilities, authority and accountability (R2A2) of the various teams from universities and TJNAF working on specific components, e.g. the interplay between coil design and physics simulations, and ensure their continued involvement throughout the project.

The simulation tools are critical for the optimal design of the spectrometer and to inform engineering tolerances. The project is encouraged to further develop the tools to allow rapid feedback to the design team, both for the near-term design needs as the project proceeds towards CD-2, but also to guide decisions based on as-built hardware that arrives during construction.

It may be possible to use the physics simulations tools to identify limits on allowable total magnetization in the various regions of the spectrometer, which can then be used by engineering as a budget for the selection and usage of magnetic materials such as steels.

The target group is highly experienced and can build on what they have learned from the Q-Weak target.

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The Committee suggested that the decision to forego testing the target system with liquid neon be reviewed and confirmed by a safety committee.

The conceptual design of the target appears sound. It is based on the successful Q-Weak design and will be executed by the same personnel. There are no obvious showstoppers, although a significant amount of engineering is still required before CD-2 to complete the design.

The Committee encouraged the project to proceed quickly with the comparative analysis between the "hybrid" and "segmented" Torus design, as the down-select decision will likely impact many downstream decisions, in particular with the planned vendor procurement stages. This is particularly important in view of the tight coupling between physics requirements and final magnet/support design.

The project intends to use a single vendor for the toroid coils. Given the high visibility and tight production schedule, the Committee strongly encouraged the team to plan for significant on-site presence so that issues are identified and addressed early, similar to what was done in CLAS12. The procurement contract should provide the flexibility to address issues in a timely manner.

It may be highly informative to include: 1) a detailed test plan for the prototype coil evaluation, including driving well beyond design current to probe actual operational limits, and 2) to perform destructive post-mortem inspection of the coil, for example in the tightest bend regions, to evaluate for example conductor deformations and coilpack impregnation quality.

The project should use the simulation capabilities to check the tolerances on the dimensions of the coils for the downstream toroid to determine if looser tolerances can be supported, possibly resulting in a cost reduction.

The project should evaluate whether residual radioactivity will be important when replacing a component, which has suffered radiation damage.

The Committee encouraged Laboratory management to identify and commit the space to be used for outside-the-hall assembly, especially for the DS toroid.

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2.1.3 Recommendations

1. Enhance engineering and designer support to the target group within the next six months to advance the design off the critical path.

2. Develop a detailed, resource-loaded installation plan prior to CD-2/3.

3. Proceed to CD-1.

2.2 Detectors, DAQ, and Infrastructure

2.2.1 Findings

The scientific case for MOLLER continues to be outstanding and extremely compelling. It provides a unique window for physics beyond the standard model with sensitivities not accessible in other accelerator facilities in the foreseeable future.

Details of the integrating and tracking detector systems (WBS 1.04 and 1.05), infrastructure (WBS 1.06), and DAQ and trigger (WBS 1.07) overall scope, budgets, schedule, risks and interfaces were presented by the Level 2 managers. Technical presentations for the integrating and tracking detector systems, DAQ and trigger, and shielding followed in the breakout session.

Integrating Detectors

The main thin quartz 6-ring Cerenkov and thick ShowerMax integrating detectors are based on proven technologies, and do not represent a technical risk.

The detectors include an air light guide coupling a quartz-face photomultiplier tube (PMT) to the thin quartz.

Qualification of a second vendor for the quartz is being considered—this would include optical and radiation-tolerance considerations.

Prototyping of the critical ring 5 thin quartz detector units is planned.

The thin quartz detectors will experience final doses as high as 170 MRad in ring 2 and 70 MRad in ring 5. Radiation testing of all detector components (quartz, light guide, and electronics) has been done and is planned for future prototypes.

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The tracking detector system is composed of three components: 1) four layers of 7-sector triple GEM detectors on rotatable stages; 2) pion Cerenkov detectors, with trigger scintillator-GEM pairs in two sectors; and 3) the scanner detector. All of these are established technologies.

GEM detectors are only for use in counting mode. The Pion detectors and scanner detector can be used during both integrating mode measurement time, and in counting mode.

A set of sieve slits are being designed, with a number of different hole patterns, to provide efficiency, orientation, and full area checks of the spectrometer acceptance.

The choice of GEM technology for tracking detectors is well motivated. The planned layout with seven sectors is constrained by cost and focuses on reusing existing developments and even components.

During integrating mode (asymmetry) measurements, GEM detectors slide on rails radially out of the flux region.

GEM detectors will be instrumented with electronics from SBS. MOLLER requires ~50k channels; in excess of 120k channels will be available from SBS.

DAQ and Trigger

The data acquisition (DAQ) system includes two separate DAQs, one for production (integration) mode and one for counting mode. The DAQ systems are built using the CODA (CEBAF Online Data Acquisition) hardware and software framework.

Integration mode DAQ and trigger requires collection and transfer of 100% of the helicity window data, without deadtime, at a helicity flip rate of 1.92 kHz.

The counting mode DAQ must support triggers derived from trigger scintillators, quartz detectors or pulsers at rates from 10kHz to 300 kHz.

Fully corrected asymmetry analysis with 100% throughput is required, with disk space to hold results spanning several days.

Integrating ADCs are the next generation of Q-Weak ADC modules and are built by TRIUMF. Key improvements from the previous generation are increased input bandwidth (now approximately 1MHz) and increased ADC sampling rate (now 15Msps).

A two-channel prototype of the new integrating ADC is to be tested this year by the University of Manitoba and TRIUMF. A complete schematic exists and firmware development is underway. PCB layout is beginning for the full board.

Counting mode electronics uses the standard TJNAF pipelined FADC and VXS Electron Trigger Readout Board plus VXS-based trigger processors.

GEM readout uses standard TJNAF multipurpose digitizer modules.

Helicity-correlated feedback requires ten second accumulation and readout. Information from the injector is included.

Requirements for the workstation for helicity-correlated feedback, for the several (ten) workstations for data quality monitoring and monitoring transverse beam polarization, and for disk storage are established. All requirements are met by the CODA framework noted above.

Scattered beam monitors (small and large angle monitors and diffuse beam monitors) fall under the scope of WBS 1.07. Detectors are small quartz + light airguide + PMT assemblies very similar to integrating detectors.

MOLLER has a potential opportunity to receive funding from the NSF mid-scale project program. If this funding is received, a portion of the GEM modules, trigger scintillators, and detector supports of the tracking detectors, as well as a portion of the ShowerMax integrating detectors, and DAQ and trigger will be removed from the DOE MIE scope.

Infrastructure

Infrastructure (WBS 1.06) includes incoming beamline modifications, hall modifications, particle shielding and electronics hut, cables and low-voltage/high-voltage power supplies and detector frames and supports. Installation of the experiment is also included in this WBS.

Shielding requirements have been evaluated using GEANT4 simulations. Current dose estimates are a factor of five below the limit for expecting damage effects.

Shielding studies show that the allowable dose at the TJNAF site boundary will not be exceeded. Detailed checks by the RadCon group are proceeding. Checks between results derived from GEANT4 and those from FLUKA have been made and show agreement within a factor of two.

Dose in the bunker for magnet power supplies is calculated to be 109 1 MeV neq, which is acceptable for standard commercial high-current power supplies.

Shielding materials include standard concrete blocks, lead shield walls downstream of the target and monolithic collimators. Examination of certain materials choices, in particular the lead for activation and proper disposal post-experiment, are under study.

Dependencies with ongoing TJNAF upgrades are being tracked by the infrastructure team. This includes low-conductivity water (LCW) and power work in Hall A, injector upgrades, Compton and MOLLER polarimeter upgrades, upgraded raster system, and a new End Station Refrigerator (ESR2). ESR2 is a critical dependency to enable use of the high-power LH2 target.

2.2.2 Comments

The maturity of the detector systems design, DAQ and trigger, and the detail of the planned implementation is very impressive, particularly for this early stage of the project.

The MOLLER project team and scientific collaboration consists of members with extensive expertise and excellent track records in performing high precision parity-violating experiments at both TJNAF and SLAC (E158). The assembled project team has the required expertise and experience to successfully execute the final design and construction.

As the accelerator facility, which has the technical expertise and infrastructure for delivering high-quality polarized beams for precision parity-violating experiments, TJNAF is the ideal location for performing the MOLLER experiment.

The scientific goals articulated in the 2014 MOLLER proposal submitted to DOE in 2014 are likely to be successfully accomplished based on the Conceptual Design. The threshold and objective Key Performance Parameters (KPPs) for the detectors and DAQ are appropriately defined and provide scope contingency to the project. The Ultimate Performance Parameters (UPPs) are aligned with the ultimate MOLLER scientific goals.

Not enough details were presented on the estimated systematic errors, in particular, there is no information on the uncertainty associated with these systematic errors in addition to the central values. While it is expected at the CD-1 stage (conceptual design), it will be essential to present further information to support the estimates of the systematic uncertainties prior to CD-2 and should be included in the Technical Design Report.

While the KPPs for the integrating MOLLER ring detectors and the GEM detectors are clearly defined, it is not clear how the performance requirements of the other detector components, including the ShowerMax and pion detectors are quantified. Additional studies to quantify the impact of the performance of these detector systems on the ultimate sensitivity of the experiment should be considered prior to CD-2.

The adopted approach of using established detector technologies and electronics systems is a sound one, and greatly reduces potential risks to the project. At the same time, care has been taken to confirm that these detector technologies will deliver on the physics goals of the experiment, which was clearly communicated.

While the detector technologies planned for MOLLER are well-established, the project should re-evaluate technical risks that could impact their progress. While these may be a low likelihood, a detector system with no risks associated with not meeting specifications seems unrealistic. An updated risk evaluation should be prepared prior to CD-2.

The detailed design of the spectrometer and geometry of the final detector systems are very closely coupled. As the detailed interface control documents are still being developed, the project needs to be very careful to ensure that changes during design, which impact other subsystems are communicated promptly to all affected parties. The current approach is to have a number of people attending all relevant meetings to maintain a comprehensive view of the project, which is a good approach. The project team may also want to consider advancing development of draft Integrated Control Documents to capture key areas of coupling.

The SBS-based front-end electronics APV-chip readout system for GEM readout is considered to be used equipment. This is an understandable choice but has a risk associated with it. It assumes that APV chips are fully functioning after SBS even though 17k channels (approximately 130 readout chips) are provided from the University of Virginia (UVA). The risk associated with this choice and a risk mitigation plan has not been fully presented.

UVA has a strong track record at TJNAF for building GEM detectors. Building a GEM detector system requires a great deal of care in Quality Assurance components and a great deal of care during the assembly. The effort will significantly benefit if the effort is shared with other institutions since UVA also has other significant responsibilities, such as SoLID (Solenoidal Large Intensity Device) and other future commitments.

The GEM detector efforts heavily rely on the delivery of components from CERN. A commitment from the CERN photolithographic group is essential. This holds for the GEM detectors and the two-dimensional board and potentially mechanical frames—it is not clear if those are also acquired from CERN. A focus on maintaining and establishing good communication as the project progresses will be essential.

Using the same vendor/manufacturer from Italy on the front-end electronics/hybrid system fabrication as for SBS is the right choice. A commitment will be necessary as the project proceeds.

The plan to build the DAQ system based on CODA and established electronics modules ensures minimal risk to the project, without compromising any required performance.

The importance of coordination between the project and the CEBAF facility is clearly understood by the project. The management support and inclusion of key Hall A personnel in the project team is evidence of this. The project should work to ensure that this communication remains strong.

Installation of the experiment falls under the Infrastructure WBS area. The project team should consider separating the infrastructure and installation parts of the WBS and possibly having different CAMs for these functions.

The schedule for installation of the experiment is very tight. The project team is going to need to keep a close eye on the removal of the SBS equipment and the installation schedule. A detailed installation plan will be needed before moving to CD-2/3.

The project team may consider adding external milestones related to the SBS removal to the P6 schedule to be able to note any future effects on their critical path, particularly when the MOLLER experiment reaches the installation phase.

Good polarization behavior for the re-configured beamline is critical to the MOLLER experiment. While this falls outside of the direct project scope, the project team will want to closely monitor the commissioning and performance of the beamline and consider adding key commissioning milestones to the P6 schedule.

2.2.3 Recommendation

4. Proceed to CD-1.

3. COST and SCHEDULE, PROJECT MANAGEMENT and ENVIRONMENT, SAFETY and HEALTH

3.1 Findings

PROJECT STATUS as of September 2020		
Project Type	MIE	
CD-1	Planned: 1QFY2021	Actual: TBD
CD-2	Planned: 2QFY2023	Actual: TBD
CD-3	Planned: 2QFY2023	Actual: TBD
CD-4	Planned: 4QFY2027	Actual: TBD
TPC Percent Complete	Planned: 1.9%	Actual: 1.9%
TPC Cost to Date	$1.0M	
TPC Committed to Date	$1.0M	
TPC	$51.0M	
TEC	$49.5M	
Contingency Cost (w/Mgmt Reserve)	$13.3M	100% to go
Contingency Schedule on CD-4	25 months	
CPI Cumulative	N/A	
SPI Cumulative	N/A	

MOLLER is a DOE Major Item of Equipment (MIE) project at TJNAF that received CD-0 in December 2016. The project has an established Integrated Project Team (IPT) and a Federal Project Director (FPD) has been assigned. The project team contains a Project Manager, Deputy Project Manager, Project Engineer, and Safety Lead. The TJNAF Project Management Office provides Project Controls and TJNAF Procurement is an overhead function.

The project team developed a Work Breakdown Structure (WBS) that includes all required project scope including a liquid hydrogen target, a resistive water-cooled toroid spectrometer magnet, Integrating Detectors, Tracking Detectors, Hall A Infrastructure and Integration, and DAQ and trigger.

The project team developed KPPs including threshold and objective criteria, and also identified UPPs for full scientific discovery potential. The KPPs include some scope contingency for thin quartz, ShowerMax, and GEM modules. A few other possibilities were mentioned as candidates for scope contingency and the total potential savings was estimated to be about $2 million.

The project team developed the required documentation to effectively deliver the project (Preliminary Project Execution Plan (PPEP), Risk Management Plan, and Preliminary Hazard Analysis Report (PHAR)).

The project has a point estimate Total Project Cost (TPC) of $51.2 million, shown below by WBS. Cost Contingency is $13.3 million, which is 35% of work to go. Estimate uncertainty accounts for 28% of the cost contingency being carried. The project team developed a list of dependencies that are required to be funded outside of project funding.

Table 3-1. WBS

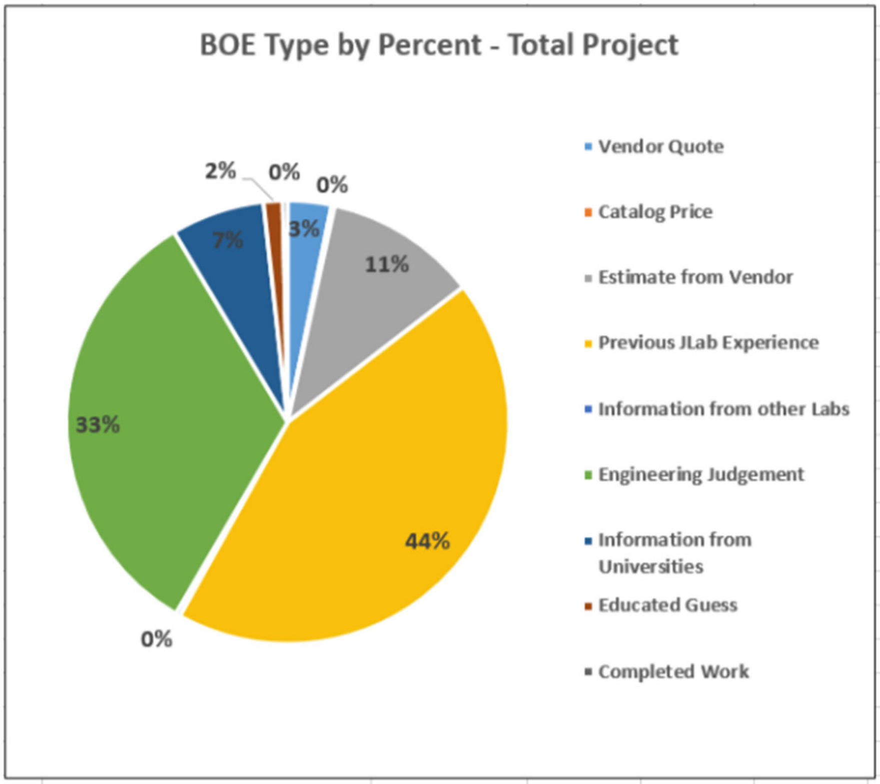
WBS	WBS Title	Total TY $K
1.01	Project Management	4,142
1.02	Liquid Hydrogen Target	3,777
1.03	Spectrometer	12,230
1.04	Integrating Detectors	3,306
1.05	Tracking Detectors	2,620
1.06	HALL A Infrastructure and Integration	7,912
1.07	DAQ and Trigger	2,258
	TEC	**36,245**
	TEC Contingency (37%)	13,254
	TEC w/Contingency	**49,500**
1.13.01	R&D and CDR	1,405
1.13.02	Project Closeout	177
	OPC	**1,581**
	OPC Contingency (8%)	119
	OPC w/Contingency	**1,700**
TPC TOTAL (TY $K)		**51,200**

The project team identified an opportunity to reduce the TPC with the delivery of portions of project scope through a National Science Foundation (NSF) grant, as well as funding from a CFI/Research Manitoba grant. Decisions from the NSF and CFI are expected by the end of the calendar year.

The project has a cost range of $42.0-60.1 million based on project definition that is at the low end of Class 2, from the DOE Cost Estimating Guide. The project definition was estimated to be in the range of 39-62%, based largely on CAM judgement.

The project's Basis of Estimate (see Table 3-2) is dominated by prior experience (44%) and engineering judgement (33%). vendor budgetary estimates are 11% of the estimate.

Table 3-2. Basis of Estimate



The project has an early finish CD-4 date of August 2025. The Level 1 milestone date for CD-4 is August 2027, resulting in 24 months of schedule contingency.

A labor profile was developed with personnel assigned by skill category to meet the project's needs. Some subcontract labor will be required to complete the project as planned.

SBS installation in Hall A was delayed by five months due to COVID-19, impacting the available resources for the MOLLER project.

A critical path schedule was developed. It runs through CEBAF operations, Hall A modifications, and equipment installations. CEBAF operation is expected to run through 2024.

The project has an active risk register. There are 66 discrete risks being tracked, five retired and 61 active. Four high risks were identified including funding profile issues, staging area availability, shielding material adequacy and detector power supply grounding.

Monte Carlo analysis of the cost and schedule risks was performed. P80 requires \$11.3 million of cost contingency and 11 months of schedule contingency. The project currently carries \$13.3 million and 24 months of contingency.

The project utilizes Primavera (P6), Deltek Cost Point, and Cobra for cost and schedule planning, tracking and integration.

The P6 schedule is resource loaded with FY 2019 rates and escalated at 3% through the out years. Project planning accounted for COVID-19 impacts through FY 2021. The project schedule consists of 1,773 activities inclusive of the REQN, AWARD, and ACCEPT tasks.

Acumen Fuse and the P6 schedule log are used for schedule analysis and quality checks. The current version of the schedule has no lags or leads, no negative float, and only one hard constraint from the CD-4 Level 1 Milestone date.

Project controls and project analysts are provided by the Project Management Office. The Project Controls Analyst (PCA) will soon become the interim Project Management Office Manager. A replacement has been hired to backfill the PCA position.

TJNAF has a certified Earned Value Management System (EVMS) that has been in place since 2008. The Project Control System Manual is updated annually. The project uses a web-based CAM Notebook and requires online, practical, and annual refresher training for the CAMs. The CAMs have yet to receive this training. The project plans to begin EVMS reporting prior to the CD-2/3 requirement.

JLAB Project Management Qualification (JPMQ) provides a fundamental project management knowledge base. It includes a three-part curriculum that includes an introduction course, ten online courses, and an instructor led integration course. Only the project manager has had prior CAM experience.

The project team has a qualified Project Safety Officer who attends Hall A weekly meetings, participates in the TJNAF Lessons Learned process, and receives “Safety Flashes” from the ES&H group for DOE Lessons Learned. A National Environmental Policy Act (NEPA) analysis was performed and the project has been granted a Categorical Exclusion based on criteria B1.31 of 10 CFR 1021 subpart D.

The project team has a signed PHAR that will continue to be reviewed and updated throughout the project. COVID-19 is not currently addressed in the PHAR. The project adheres to TJNAF’s Integrated Safety Management (ISM) Program and ES&H Manual.

3.2 Comments

The project is being managed by a strong team.

The preferred alternative to execute MOLLER at TJNAF is reasonable but the lifecycle cost has only been presented for the preferred alternative. A comparison of alternative costs in present value has been requested of other projects prior to completing an ESAAB.

The KPPs are well developed for a project at this stage.

The project should update the Office of Science numbers throughout the PPEP. The SC numbers have recently changed. Removal of names from organization charts in the PPEP should also be considered.

The project has a cost range of $42.0-60.1 million derived from the -5% to + 15% range of a Class 2 project in the DOE Cost Estimating Guide. The project may better be defined as Class 3 or Class 2/3. However, the high end of the range equates to 66% contingency on the Baseline at Completion (BAC) that should be adequate for a project at this stage and this level of risk.

The project schedule was analyzed with Acumen Fuse and had a schedule quality score of 86%, which is very good. However, after cleaning up the redundant logic using Fuse's cleanse feature a 92% schedule quality was obtained.

The Committee was able to confirm the P6 critical path provided by pdf after a milestone correction was made by the project team.

The project should improve clarity in roles, responsibility, authority, and accountability (R2A2) of the various teams from universities and TJNAF, particularly when collaborating on a common component. The project team should work with the institutions and the program office to ensure their continued involvement throughout the project.

The project team should consider updating the risk registry with an Expected Monetary Value (EMV) column to allow for a quick comparison with existing contingency levels to ensure remaining contingency is sufficient to cover project risks. This will need to be done in conjunction with an analysis of the estimate uncertainty as well.

Scope contingency was not explicitly included in any of the presentations but the project manager was able to describe the available possibilities. The project should document the various scope contingency possibilities, including their cost and associated risk, and explicitly present this at the next DOE/SC review.

The ESH and quality teams should consider trips to partner universities to establish contact with their counterparts, share lessons learned and heighten awareness of ESH&Q issues across the project.

The CAMs should complete the required training on EVMS well before CD-2.

The PHAR should be updated to include COVID-19.

The project does not have an identified quality professional on board to guide development of a tailored quality plan and provide support when questions and issues arise. This should be rectified prior to CD-2.

The design of the hydrogen target is driving the project's CD-3 date, causing other systems with completed designs to wait and potentially lose momentum. This is largely a resource issue at the level of one or two people with the requisite experience. The project and TJNAF are encouraged to work together to address this resource bottleneck to bring the hydrogen target CD-3 schedule more in line with the other systems.

The project should perform load-leveling on the schedule and evaluate opportunities to accelerate the design schedule to enable more realistic procurement and installation dates. The PPEP Section 8.2.1 should be updated addressing the P80 estimates obtained from the Monte Carlo analysis.

3.3 Recommendations

5. Update the PPEP prior to CD-1.

6. Add a Quality Assurance Professional to the project before CD-2/3.

7. Perform load-leveling on the schedule and evaluate opportunities to accelerate the design schedule, within the next six months, to enable a more realistic and optimized procurement and installation schedule.

8. Proceed to CD-1.

Appendix A Charge Memo

United States Government **Department of Energy**

memorandum

DATE: August 11, 2020

REPLY TO ATTN OF: Office of Nuclear Physics, SC-36

SUBJECT: Project Review of the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER)

TO: Kurt Fisher, Acting Director
Office of Project Assessment, SC-23

I request that your office organize and conduct a Department of Energy (DOE) Office of Science (SC) review of the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Major Item of Equipment (MIE). The purpose of this review is to determine if the project has fulfilled the requirements for Critical Decision-1 (CD-1), "Approve Alternative Selection and Cost Range," and is ready to request CD-1 approval.

The project received CD-0, "Approve Mission Need," on November 18, 2016, with a Total Project Cost (TPC) in the range of $25 to $35 million and a four-year profile with a Fiscal Year (FY) 2022 completion date (after a FY 2018 start). The MOLLER MIE will be an apparatus to measure parity-violation in electron-electron scattering to unprecedented precision at the facilities of CEBAF at TJNAF, closing a severe capability gap and providing a unique opportunity to probe physics beyond the Standard Model, with a unique window as to possible new physics up to multi-TeV scales. Its primary measurement would be the most sensitive low energy measurement of a flavor-conserving purely leptonic interaction in the world.

In carrying out its charge, the review panel is requested to consider the following main topics:

1. Does the MOLLER conceptual design meet the scientific goals as described in the Moller Science Proposal submitted to the DOE in 2013? Are the threshold and objective Key Performance Parameters (KPPs) and Ultimate Performance Parameters (UPPs) appropriately defined?
2. Is the project's conceptual design technically sound and feasible? Are technical risks properly identified and are appropriate mitigation strategies in place? Are the interfaces with the CEBAF facility appropriately understood?
3. Are the cost and schedule estimates credible? Do they include adequate scope, cost, and schedule contingency? Is the cost range clearly identified and is it appropriate?
4. Is the project being properly managed? Is there a capable team in place to effectively manage risks and ensure qualitly?
5. Is environment, safety, and health (ES&H) being properly addressed given the project's current stage of development?
6. Has the project met all the CD-1 prerequisites and are they positioned to request CD-1 approval?
7. Are there other issues of note relating to the overall project plans?

The Office of Nuclear Physics' Program Manager responsible for MOLLER, Elizabeth Bartosz, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your panel's report within 60 days of the review's conclusion.

Timothy J. Hallman
Associate Director of the Office of Science
for Nuclear Physics

TIMOTHY HALLMAN
Digitally signed by TIMOTHY HALLMAN
Date: 2020.08.11 10:21:58 -04'00'

cc: E. Merrill, SC-23
E. Bartosz, SC-36.2
J. Gillo, SC-36.2
P. Sorensen, SC-36.1
B. Foley, TJSO

Appendix B Review Committee

DOE/SC CD-1 Review of the
Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Project at TJNAF
October 13-15, 2020

Ethan Merrill, DOE/OPA, Chairperson

SC1
Target and Spectrometer

* Soren Prestemon, LBNL
Doug Beck, U of Illinois
Carsten Hast, SLAC
Wolfgang Lorenzon, U of Mich
Peter Wanderer, BNL

SC2
Detectors, DAQ, and Infrastructure

* Heather Crawford, LBNL
Jen-Chieh Peng, U of Illinois
Bernd Surrow, Temple U.
Glenn Young, BNL

SC3
ESH, Cost and Schedule,
Project Management

* Ron Ray, FNAL
Jeff Bramble, LBNL
Whitney Hughes, PNNL
Tony Indelicato, DOE/PSO
Steve Langish, PPPL

Observers

Jehanne Gillo, DOE/NP
Elizabeth Bartosz, DOE/NP
Gulshan Rai, DOE/NP
Paul Sorensen, DOE/NP
Stan Dickson, DOE/BASO

LEGEND

SC Subcommittee
* Chairperson

Count: 15 (excluding observers)

Appendix C Review Agenda

DOE/SC CD-1 Review of the
Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Project at TJNAF Project
October 13-15, 2020

AGENDA

Tuesday, October 13 – Remote Meeting (Bluejeans)

10:30am	Executive Session for Review Committee (Committee, ONP, TJSO)	
11:30am	Welcome from JLab Management (Stuart Henderson, Bob McKeown, Allison Lung)	
11:40am	Review of Agenda (Jim)	
11:45pm	Project Overview	James Fast
12:20am	MOLLER Science Program	Krishna Kumar
1:05pm	Cost and Schedule	James Fast
1:30pm	Executive Session and Working Lunch Break	
2:30pm	Risk Management and Analysis	Jessie Butler
2:50pm	Target – Scope, Schedule and Budget	Silviu Covrig Dusa
3:10pm	Spectrometer – Scope, Schedule and Budget	Ruben Fair
3:30pm	Detectors – Scope, Schedule and Budget	Carl Zorn
3:50pm	Infrastructure – Scope, Schedule and Budget	Javier Gomez
4:10pm	DAQ/Trigger – Scope, Schedule and Budget	Bob Michaels
4:30pm	Break	
4:50pm	Systems Engineering and Interfaces	Robin Wines
5:10pm	Project Dependencies – JLab Perspective	Rolf Ent
5:30pm	Executive Session for Review Committee	
6:30pm	Adjourn	

Wednesday, October 14

10:30am Response to homework (as needed)
11:00am Executive Session for Review Committee (Committee, ONP, TJSO)
11:30am Breakout Sessions (technical focus, ~15+5 min presentations + Q&A time)
SC-1 Management (Jim Fast, Jessie Butler, Robin Wines)
JLab Project Management Office and EVMS System (Kelly Krug, JLab)
MOLLER Cost and Schedule Development (Phil Kessler, JLab)
MOLLER ES&H (Ed Folts, JLab)
SC-2 Target and Spectrometer (Silviu Covrig Dusa, Ruben Fair)
Liquid Hydrogen and Solid Targets (Silviu Covrig Dusa, JLab)
Spectrometer Physics Design (Julliette Mammei, U. Manitoba)
Magnet, Collimator and Beampipe Engineering (David Kashy, JLab)
Downstream Coil Prototype (Ernie Ihloff, MIT-Bates)
SC-3 Detectors, DAQ and Infrastructure (Carl Zorn, Bob Michaels, Javier Gomez)
Integrating Detectors (Michael Gericke, U. Manitoba)
Tracking Detectors (David Armstrong, William and Mary)
Trigger and Data Acquisition (Paul King, Ohio University)
Shielding (Ciprian Gal, Stony Brook)
1:30pm Executive Session and Working Lunch Break
2:30pm CAM interview and Cost Book drill downs (full committee, ~15 minutes each)
WBS 1.01 Project Integration and Support (Jim Fast)
WBS 1.02 Project Integration and Support (Silviu Covrig Dusa)
WBS 1.03 Project Integration and Support (Ruben Fair)
WBS 1.04 and 1.05 Detector Systems (Carl Zorn)
WBS 1.06 Project Integration and Support (Javier Gomez)
WBS 1.07 DAQ/Trigger (Bob Michaels)
4:00pm Executive Session for Review Committee
6:00pm Adjourn

Thursday, October 15

10:30am Response to homework (as needed)
11:00am Executive Session – Report Writing
1:00pm Executive Session and Working Lunch Break
2:30pm Executive Session – Group Review of Charge Questions and Recommendations
3:30pm Executive Session – Continue Report Writing
4:30pm Executive Session – Final Discussions and Page Turn
5:00pm Review Closeout with Lab Management and Project Team
6:00pm Adjourn

Appendix D MOLLER Cost Chart

WBS	WBS Title	Total TY $K
1.01	Project Management	4,142
1.02	Liquid Hydrogen Target	3,777
1.03	Spectrometer	12,230
1.04	Integrating Detectors	3,306
1.05	Tracking Detectors	2,620
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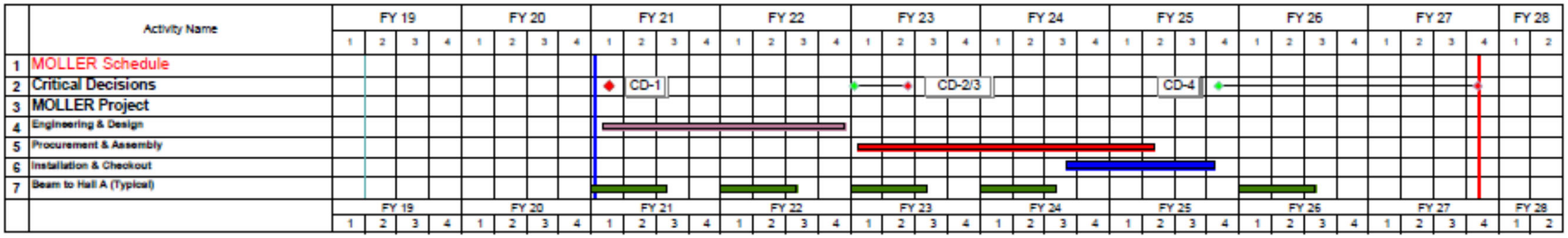
	TEC	**36,245**
	TEC Contingency (37%)	13,254
	TEC w/Contingency	**49,500**
1.13.01	R&D and CDR	1,405
1.13.02	Project Closeout	177
	OPC	**1,581**
	OPC Contingency (8%)	119
	OPC w/Contingency	**1,700**
TPC TOTAL (TY $K)		**51,200**

Appendix E MOLLER Schedule



Appendix F MOLLER Management Chart